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(54) IMAGE RECORDING APPARATUS

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B41J 29/377	(2006.01)
B41J 11/00	(2006.01)
G03G 15/00	(2006.01)

(52) U.S. Cl.

CPC ***B41J 29/377*** (2013.01); ***B41J 11/002*** (2013.01)

(58) Field of Classification Search

CPC B41J 11/02; B41J 11/04; B41J 13/076
USPC 347/102; 399/159
See application file for complete search history.

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U.S. PATENT DOCUMENTS

5,502,476	A	3/1996	Neal et al.	
8,814,347	B2 *	8/2014	Sugaya et al.	347/102

FOREIGN PATENT DOCUMENTS

JP	07-276621		10/1995	
JP	11-221914		8/1999	
JP	2009-226811		10/2009	
JP	2012077736	A1 *	6/2012	B41J 11/002

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(57) ABSTRACT

An image recording apparatus includes: a rotating drum including a hollow cylinder around which a recording medium is guided while the rotating drum rotates; a discharge head that discharges liquid onto the recording medium guided around the outer surface of the rotating drum; and an air flow generator that generates an air flow that passes through the inside of the hollow cylinder of the rotating drum. The rotating drum further includes, in the hollow cylinder, a shaft member that has an axis identical to a rotation axis of the rotating drum and supporting members that are plate-shaped and that extend from the shaft member in the radial direction of the rotating drum and support the hollow cylinder, and the rotating drum rotates in a rotation direction about the shaft member. Each of the supporting members includes at least one air hole penetrating therethrough in the rotation direction.

10 Claims, 6 Drawing Sheets

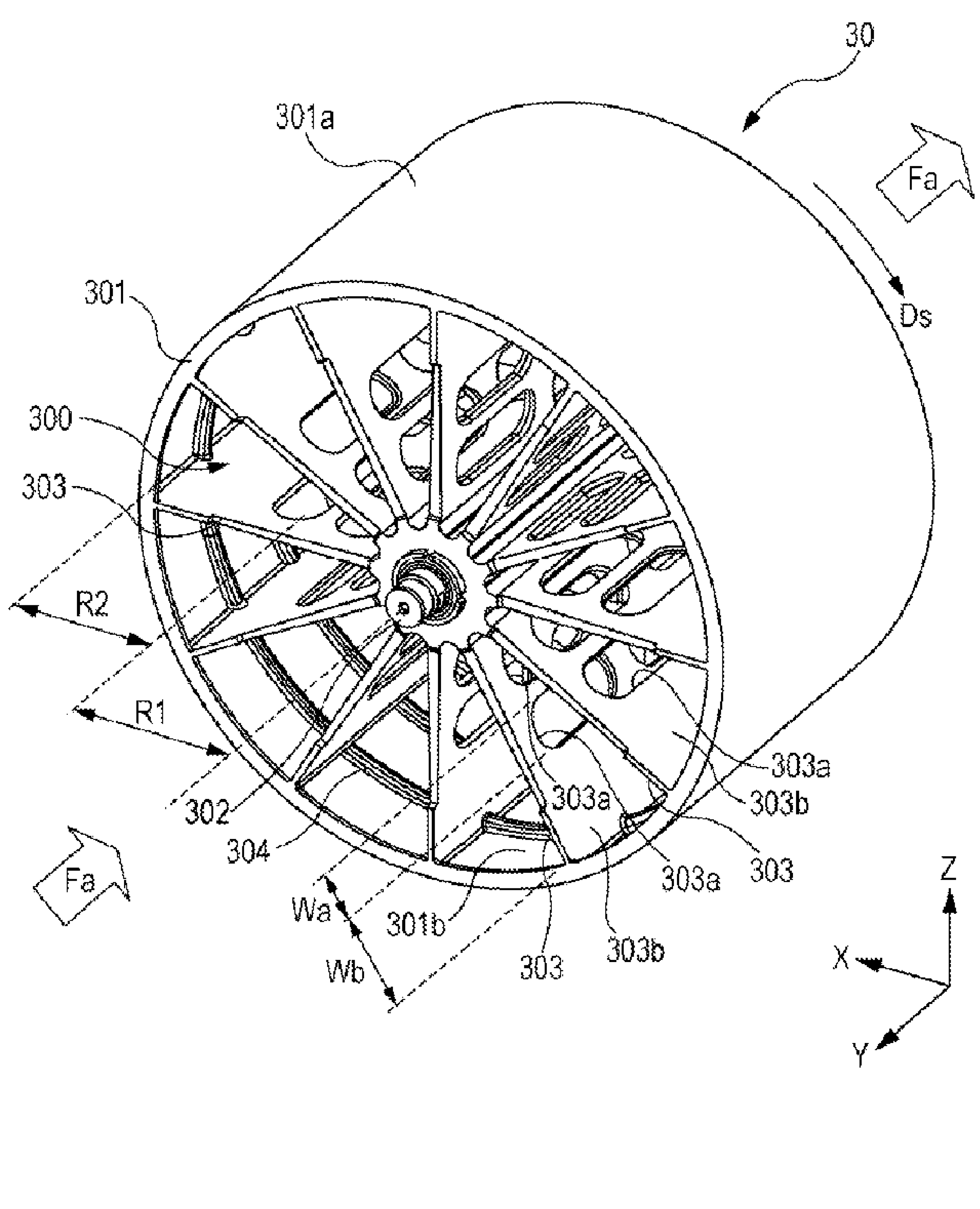
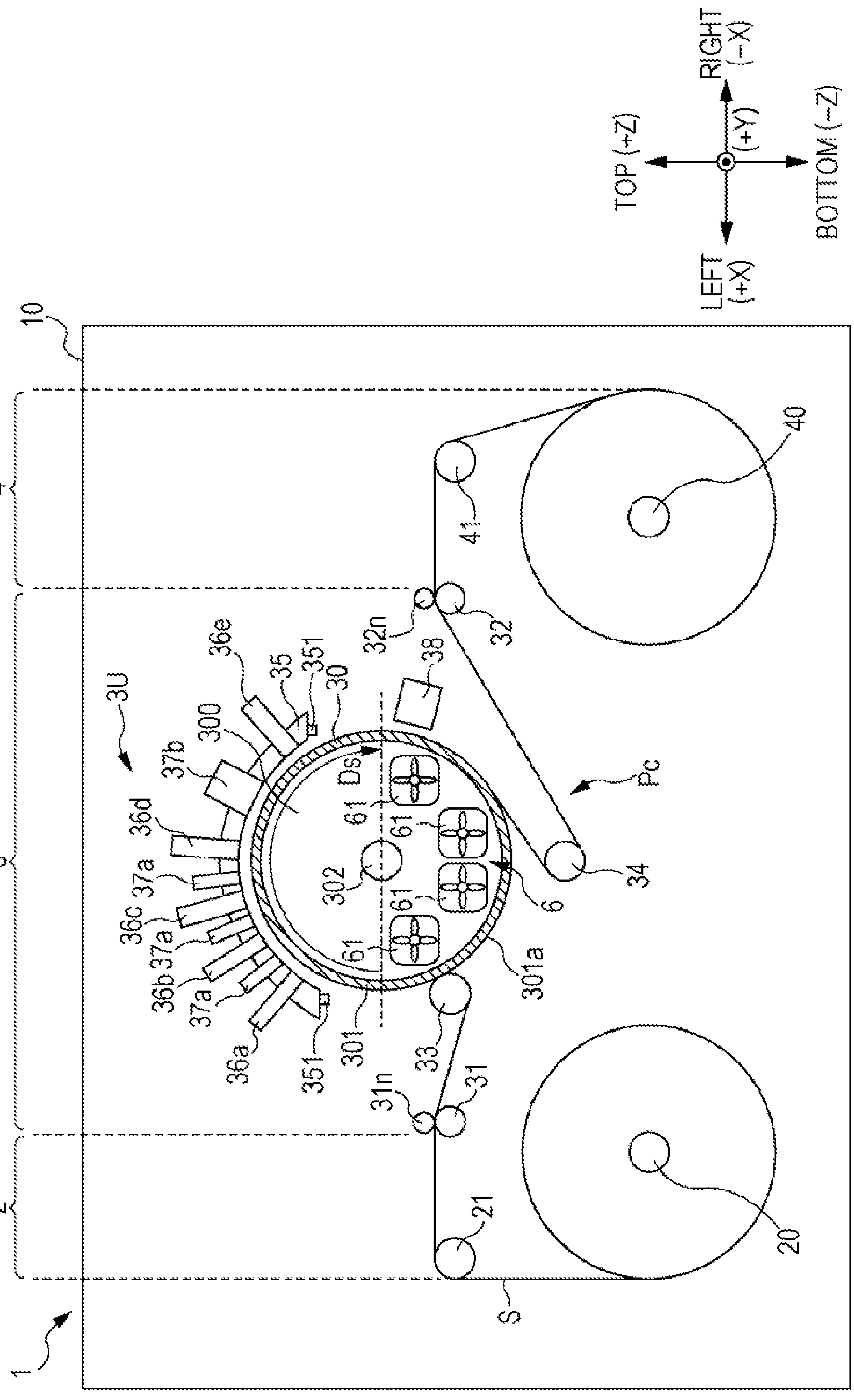


FIG. 1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(+Y)
BOTTOM (−Z)
LEFT (+X)
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3
2
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40
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32n
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34
3U
36e
35
351
30
300
37b
36d
37a
36c
36b
37a
37a
36a
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61
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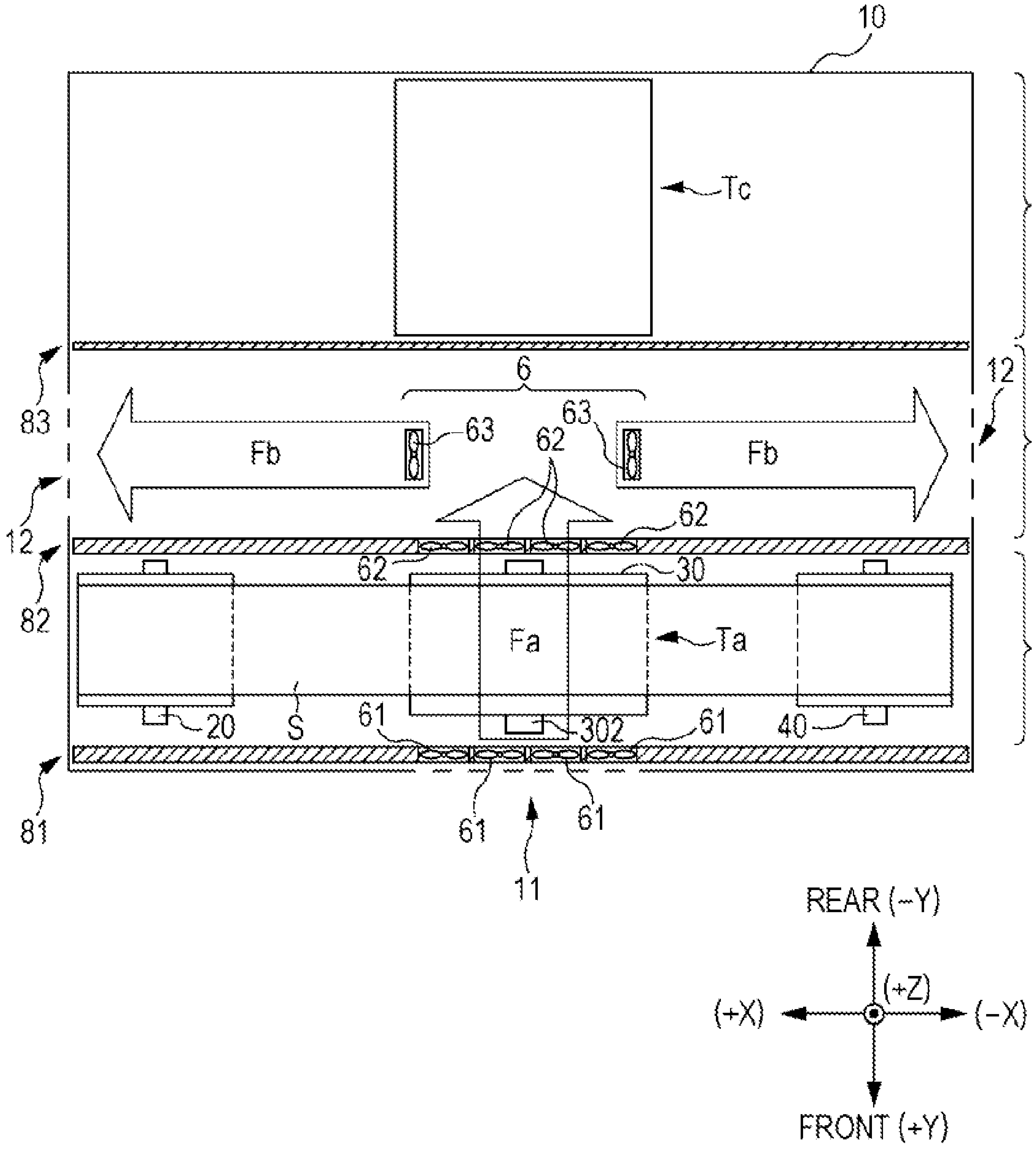
FIG. 2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Fb
Rb
12
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Ta
Ra
20
S
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61
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REAR (−Y)
(+Z)
(+X)
(−X)
FRONT (+Y)

FIG. 3

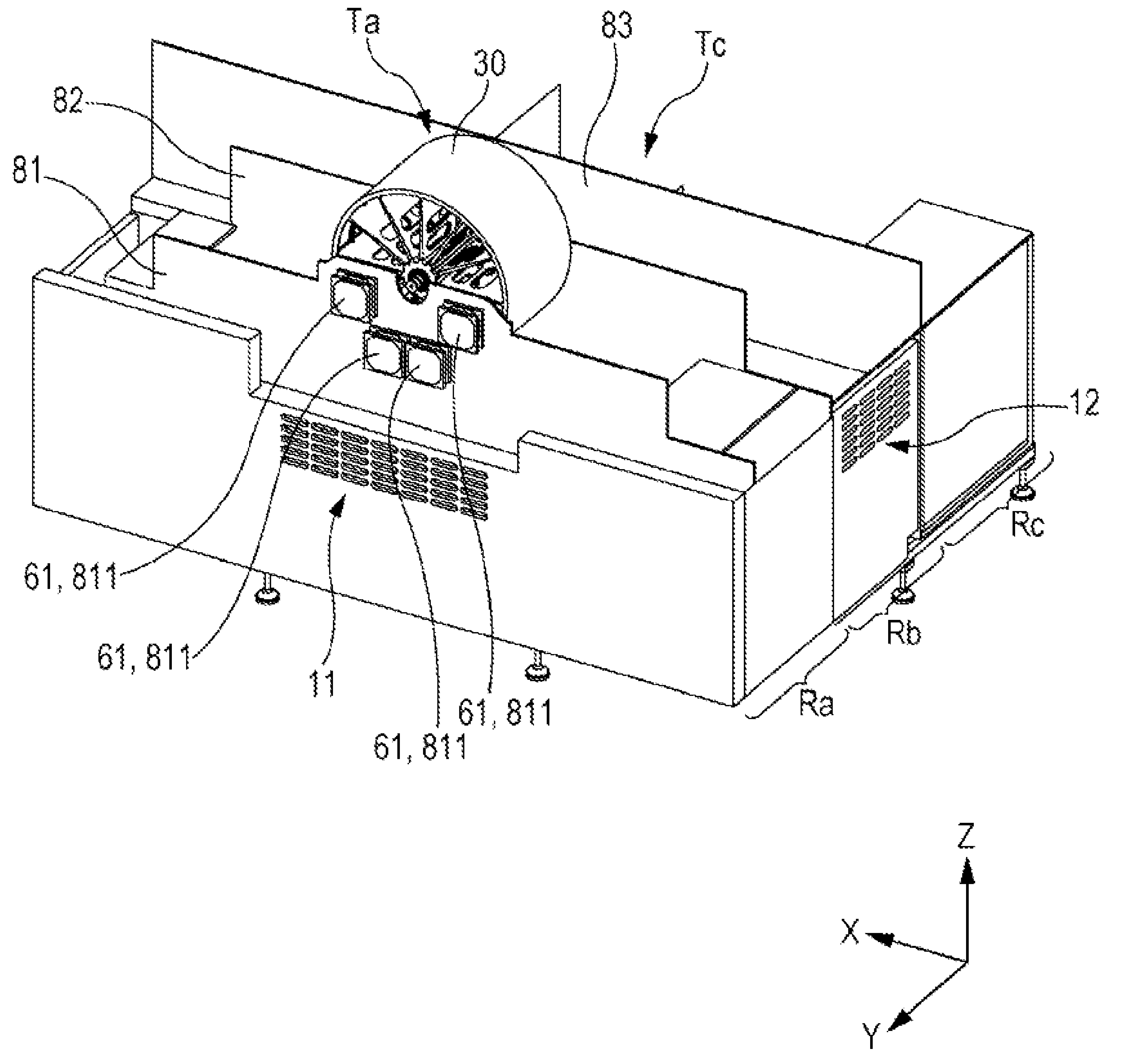


FIG. 4

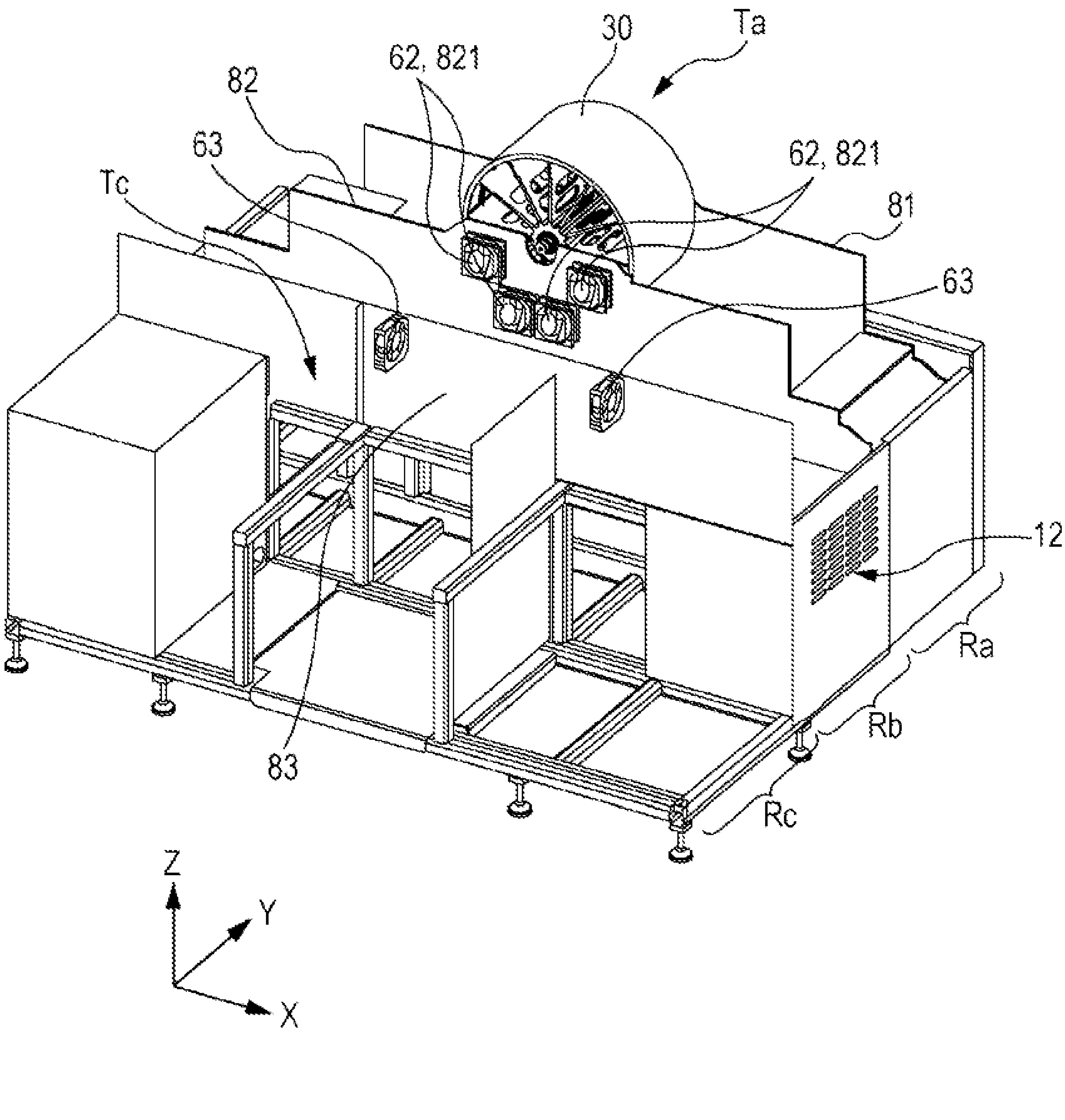
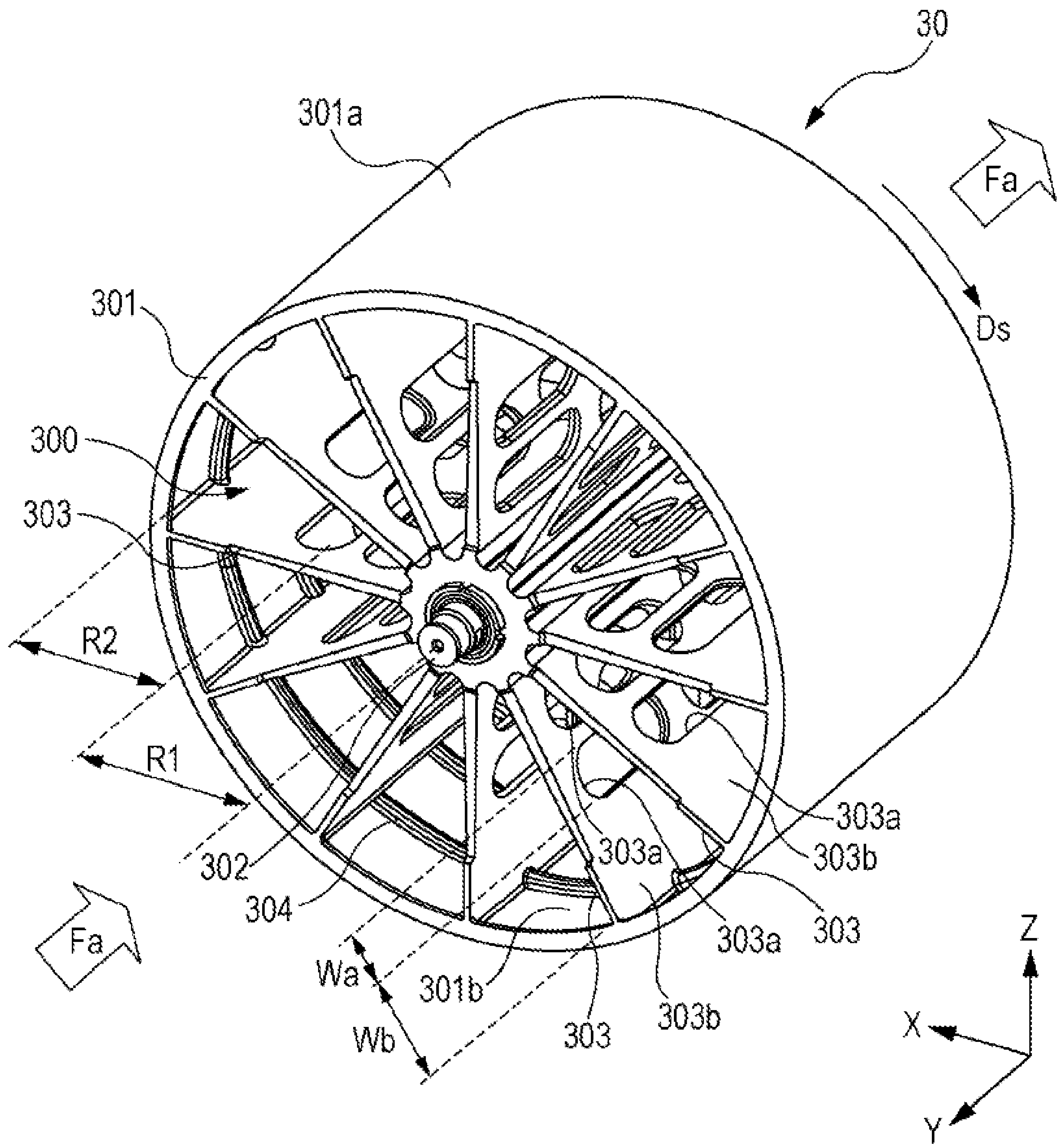


FIG. 5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R1
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303
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Y

FIG. 6

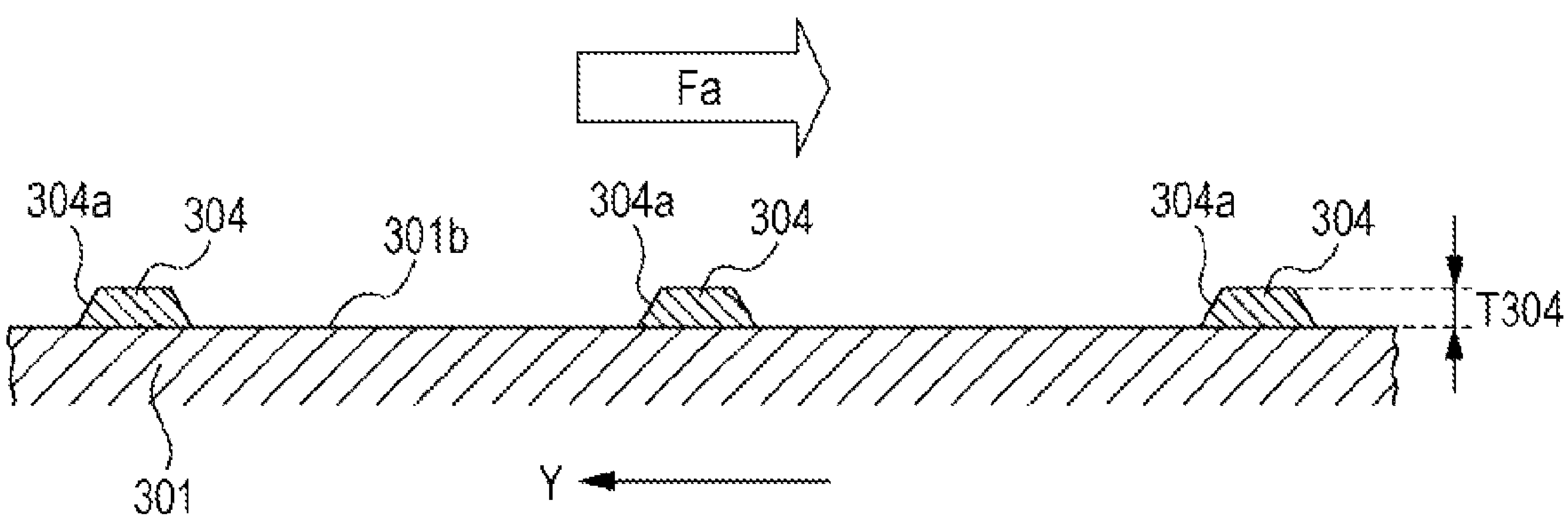

IMAGE RECORDING APPARATUS

BACKGROUND

1. Technical Field

The present invention relates to an image recording apparatus which discharges liquid from a discharge head and records an image on a recording medium supported on an outer surface of a rotating drum. In particular, the invention relates to a technique for cooling the rotating drum.

2. Related Art

U.S. Pat. No. 5,502,476 describes a printer which discharges an ink from a print head onto an outer surface of a drum to record an image. The printer prints an image on a print medium by cooling and curing ink deposited on the drum by using the drum and transferring the ink to a print medium that forms a nip with the drum. Moreover, in order to effectively cool the ink by using the drum, the drum is cooled by air flow generated using a fan. Specifically, a fan facing the hollow portion of the drum in the axial direction of the drum generates an air flow that passes through the hollow portion of the drum in the axial direction, whereby the drum is cooled (FIG. **11**).

There is an image recording apparatus which records an image on the recording medium by discharging liquid from a discharge head onto a recording medium which is guided around an outer surface of a cylindrical platen (a rotating drum). In such an image recording apparatus, when the rotating drum is heated by the heat source in the apparatus, the rotating drum thermally expands, which causes the gap between the rotating drum and the discharge head to vary, which in turn may cause the liquid to become misaligned on the recording medium. Thus, the technique of U.S. Pat. No. 5,502,476 is used to cool the rotating drum by using a fan.

However, in order to effectively cool the rotating drum by using a fan, it is required that a large amount of high-speed air flow generated by the fan passes through the hollow portion of the rotating drum to promote heat exchange between the air flow and the rotating drum. In contrast, in an image forming apparatus of U.S. Pat. No. 5,502,476, a plurality of arms are disposed radially from the rotation axis of the rotating drum in the hollow portion of the rotating drum to support an outer peripheral member (a rim) of the rotating drum. Therefore, when the rotating drum rotates in order to transport the recording medium, the arms also rotate. The rotation direction of the arms intersects (is substantially orthogonal to) the direction of the air flow, so that the rotating arms catch the air flow and stop the air flow from passing. Under these circumstances, it is not always easy to generate a large amount of high-speed air flow that is intended to pass through the hollow portion of the rotating drum and it can be difficult to efficiently cool the rotating drum.

SUMMARY

An advantage of some aspects of the invention is that, in an image recording apparatus which discharges liquid from a discharge head and records an image on a recording medium supported by an outer surface of a rotating drum, the rotating drum can be efficiently cooled.

An image recording apparatus according to an aspect of the invention includes: a rotating drum including a hollow cylinder around which a recording medium is guided while the rotating drum rotates; a discharge head, opposing an outer surface of the rotating drum, that discharges liquid onto the recording medium guided around the outer surface of the rotating drum; and an air flow generator that generates an air flow that passes through the inside of the hollow cylinder of the rotating drum. The rotating drum further includes, in the hollow cylinder, a shaft member that has an axis identical to a rotation axis of the rotating drum and supporting members that are plate-shaped and that extend from the shaft member in the radial direction of the rotating drum and support the hollow cylinder, and the rotating drum rotates in a rotation direction about the shaft member. Each of the supporting members includes at least one air hole penetrating therethrough in the rotation direction.

In an aspect of the invention (the image recording apparatus) configured in this manner, the rotating drum includes the hollow cylinder around which the recording medium is guided. The discharge head discharges liquid onto the recording medium which is guided around the outer surface of the rotating drum, whereby an image can be recorded on the recording medium. Moreover, an air flow generator that generates an air flow that passes through a hollow portion (a portion inside of the hollow cylinder) of the rotating drum is provided and the rotating drum is cooled by the air flow.

However, the rotating drum includes, in the hollow portion, shaft members that have an axis identical to the rotation axis of the rotating drum and supporting members that are plate-shaped, and that extend from the shaft member in the radial direction and support the hollow cylinder, and the rotating drum rotates in a rotation direction about the shaft member. Therefore, when the rotating drum rotates, the supporting members in the hollow portion also rotate in the rotation direction. In addition, the rotation direction of the supporting members is a direction intersecting (substantially orthogonal to) the direction of the air flow passing through the hollow portion, whereby the rotating supporting members may block the air flow.

In this respect, according to an aspect of the invention, the air holes penetrating through the supporting member in the rotation direction are disposed. Therefore, the air flow generated by the air flow generator passes through the air holes in the rotation direction, thereby avoiding being caught by the supporting members rotating in the rotation direction and is able to pass through the hollow portion. As a result, a large amount of the high-speed air flow can be generated and introduced into the hollow portion of the rotating drum, whereby the rotating drum can be efficiently cooled.

As mentioned above, heating of the rotating drum becomes a problem when the heated rotating drum thermally expands, the gap between the rotating drum and the discharge heads may vary. In particular, expansion of the outer surface of the rotating drum considerably affects the gap between the rotating drum and the discharge head. Therefore, it is important to efficiently cool the hollow cylinder of the rotating drum. In this respect, the image recording apparatus may be configured so that the supporting members include a fin portion that does not have an air hole and that has a width that extends from the inner surface of the hollow cylinder toward the shaft member in the radial direction. In such a configuration, while a large amount of the high-speed air flow is secured in the hollow portion by the air holes disposed in a region other than the fin portion, the air flow can sufficiently impinge on a portion of the supporting members which is close to the hollow cylinder (the fin portion). As a result, the hollow cylinder can exchange heat via the fin portion by using a large amount of the high-speed air flow, whereby the hollow cylinder can be efficiently cooled.

In this case, the image recording apparatus may be configured so that the width of the fin portion in the radial direction is equal to or larger than the width of the air hole in the radial

direction. The fin portion has such a width, whereby the hollow cylinder can be efficiently reliably cooled.

From another viewpoint, the image recording apparatus may be configured so that the total area of the air holes disposed in a region of the supporting members which lies at a distance of r/2 or less from the rotation axis of the rotating drum in the radial direction is larger than the total area of the air holes disposed in a region of the supporting members which lies at a distance larger than r/2 from the rotation axis of the rotating drum, where the radius of the rotating drum is r. In such a configuration, more air holes are disposed in a region of the supporting members which is close to the center of the rotating drum, whereby the air flow does not pass through and is blown to the region of the supporting members which is close to the hollow cylinder. As a result, the hollow cylinder can exchange heat with a large amount of the high-speed air flow, whereby the hollow cylinder can be efficiently cooled.

In this respect, the image recording apparatus may be configured so that the plurality of the air holes are disposed in the radial direction between the inner surface of the hollow cylinder and the shaft member. Moreover, the image recording apparatus may be configured so that the plurality of air holes are disposed also in the axial direction. Because the plurality of air holes are disposed in this manner, the supporting members can effectively suppress blocking of the air flow, so that a large amount of the high-speed air flow can be generated in the hollow portion of the rotating drum, whereby cooling efficiency of the rotating drum can be improved.

In this respect, the image recording apparatus may be configured so that, from the above mentioned viewpoint in which the hollow cylinder of the rotating drum is efficiently cooled, the auxiliary heat dissipation member is also disposed on the inner surface of the hollow cylinder of the rotating drum in addition to the supporting members. In such a configuration, the air flow can sufficiently impinge on the auxiliary heat dissipation member disposed on the hollow cylinder, so that the hollow cylinder can exchange heat via the auxiliary heat dissipation member with a large amount of the high-speed air flow, whereby the hollow cylinder can be efficiently cooled.

Then, the image recording apparatus may be configured so that the auxiliary heat dissipation member is formed in the shape of a ring that extends over the entire periphery in the peripheral direction on the inner surface of the hollow cylinder. The auxiliary heat dissipation member is disposed in this manner to be able to promote heat exchange between the air flow and the hollow cylinder via the auxiliary heat dissipation member, whereby the hollow cylinder can be efficiently reliably cooled.

Then, the image recording apparatus may be configured so that the auxiliary heat dissipation member includes a wall surface that is inclined in the direction of the air flow and is disposed on an upstream side in the air flow direction. In such a configuration, because the wall surface is inclined in the direction of the air flow which the auxiliary heat dissipation member includes on an upstream side in the air flow direction, the wall surface of the auxiliary heat dissipation member can suppress blocking of the air flow.

Moreover, the image recording apparatus may be configured so that the discharge head further includes a light irradiator that irradiates a liquid having been discharged onto the recording medium with light, the liquid is a photo-curable liquid which generates heat when it is cured by irradiation with light, and the light irradiator irradiates a portion of the recording medium that is guided around the rotating drum with light. In such an image recording apparatus, the heat generated when the photo-curable liquid is cured heats the rotating drum, resulting in variation of the gap between the rotating drum and the discharge head. In this case, the apparatus has the above-mentioned configuration according to an aspect of the invention, so that a large amount of the high-speed air flow is generated in the hollow portion of the rotating drum, whereby the cooling efficiency of the rotating drum can be preferably improved.

In particular, if the light irradiator irradiates a portion of the recording medium that is guided around the rotating drum with light, heat is generated when the photo-curable liquid is cured. The heat heats the rotating drum, thereby causing the gap between the rotating drum and the discharge head to vary, which becomes a serious problem. In this case, the apparatus has the above-mentioned configuration according to an aspect of the invention, so that cooling efficiency of the rotating drum can be highly preferably improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

FIG. **1** is a front view schematically illustrating a schematic configuration of a printing apparatus to which the invention is applicable.

FIG. **2** is a plan view schematically illustrating the schematic configuration of the printing apparatus shown in FIG. **1**.

FIG. **3** is a front perspective view partially illustrating the schematic configuration of the printing apparatus shown in FIG. **1**.

FIG. **4** is a rear perspective view partially illustrating the schematic configuration of the printing apparatus shown in FIG. **1**.

FIG. **5** is a front perspective view partially illustrating a configuration of a rotating drum.

FIG. **6** is a Y-direction partial sectional view schematically illustrating a section of an auxiliary heat dissipation member.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

FIG. **1** is a front view schematically illustrating a schematic configuration of a printing apparatus to which the invention is applicable. An XYZ orthogonal coordinate system corresponding to a left-right direction X, a front-rear direction Y, and a vertical direction Z of a printing apparatus **1** is shown in FIG. **1** and other figures as necessary for clarity of the positional relationships between various components of the apparatus.

The printing apparatus **1** includes a feeding section **2**, a processing section **3**, and a winding section **4** arranged in the left-right direction X. These functional portions **2**, **3**, and **4** are accommodated in a housing member **10** (a casing). The feeding section **2** and the winding section **4** include a feeding shaft **20** and a winding shaft **40**, respectively. A sheet S (a web) has both ends wrapped into rolls around the feeding shaft **20** and the winding shaft **40**, respectively, and is stretched between the feeding shaft **20** and the winding shaft **40**. The sheet S stretched in this manner is transported along a path Pc from the feeding shaft **20** to the processing section **3**. In the processing section **3**, a processing unit **3**U performs recording on the sheet S and subsequently the sheet S is transported to the winding shaft **40**. The sheet S may be either a paper sheet or a film sheet. Specifically, examples of the paper sheet include bond paper, cast paper, art paper, coated paper, and the like while examples of the film sheet include synthetic paper, PET (polyethylene terephthalate), PP (polypropylene), and the like. In the following description, one surface of the sheet S on which an image is recorded is referred to as a front side while another surface is referred to as a back side.

The feeding section **2** includes the feeding shaft **20** around which the end of the sheet S is wrapped, and a driven roller **21** around which the sheet S having been drawn from the feeding shaft **20** is guided. The feeding shaft **20** supports the sheet S by wrapping the end of the sheet S therearound in a state in which the front side of the sheet S faces outside. The feeding shaft **20** rotates clockwise in FIG. **1**, whereby the sheet S wrapped around the feeding shaft **20** is fed via the driven roller **21** to the processing section **3**. In this regard, the sheet S is wrapped around the feeding shaft **20** via a core tube (not shown) detachable from the feeding shaft **20**. Therefore, when the sheet S around the feeding shaft **20** is exhausted, a new core tube around which a new sheet S is wrapped into a roll can be mounted on the feeding shaft **20**.

The processing section **3** is intended to print an image on the sheet S by performing processing properly using the processing unit **3**U disposed along the outer surface **301***a* of the rotating drum **30** while the rotating drum **30** supports the sheet S fed from the feeding section **2**. In the processing section **3**, each of a preceding drive roller **31** and a succeeding drive roller **32** are disposed on a corresponding one of both sides of the rotating drum **30**. An image is printed on the sheet S which is transported from the preceding drive roller **31** to the succeeding drive roller **32** and supported by the rotating drum **30**.

The preceding drive roller **31** includes a plurality of minute protrusions formed by thermal spraying on the outer surface and guides the sheet S fed from the feeding section **2** with the back side of the sheet S facing the preceding drive roller **31**. The preceding drive roller **31** rotates clockwise in FIG. **1**, whereby the sheet S fed from the feeding section **2** is transported downstream in the transport path. A nip roller **31***n* is disposed so as to oppose the preceding drive roller **31**. The nip roller **31***n* abuts against the front side of the sheet S in a state in which the nip roller **31***n* is urged toward the preceding drive roller **31** and the sheet S is nipped between the nip roller **31***n* and the preceding drive roller **31**. Thus, friction force between the preceding drive roller **31** and the sheet S is secured, so that the preceding drive roller **31** can reliably transport the sheet S.

The rotating drum **30** is a cylindrical drum having a center line parallel to the Y-direction. The rotating drum **30** includes a hollow portion **300** penetrating the rotating drum **30** in the axial direction Y, and the sheet S is guided around the outer surface **301***a* of a hollow cylinder **301** surrounding the hollow portion **300**. Furthermore, the rotating drum **30** includes, in the hollow portion **300**, a rotation shaft **302** extending in the axial direction, through which the center line of the cylindrical shape extends. The rotation shaft **302** is rotatably supported by a supporting device (not shown) and the rotating drum **30** rotates about the rotation shaft **302**.

The sheet S transported from the preceding drive roller **30** to the succeeding drive roller **32** is guided around the outer surface **301***a* of the rotating drum **30** with the back side of the sheet S facing the preceding drive roller **31**. The rotating drum **30** is driven to rotate in the transport direction Ds of the sheet S under friction force against the sheet S while supporting the sheet S from the back side. In this regard, in the processing section **3**, each of driven rollers **33** and **34** for turning the sheet S back are disposed on a corresponding end portion of the sheet S that is guided on the rotating drum **30**. The driven roller **33** directs the sheet S back between the preceding drive roller **31** and the rotating drum **30** with the front side of the sheet S facing the driven roller **33**. On the other hand, the driven roller **34** directs the sheet S back between the rotating drum **30** and the succeeding drive roller **32** with the front side of the sheet S facing the driven roller **34**. In this manner, the sheet S is directed back upstream and downstream of the rotating drum **30** in the transport direction Ds, whereby the length of the portion of the sheet S that is guided on the rotating drum **30** can be large.

The succeeding drive roller **32** includes a plurality of minute protrusions formed by thermal spraying on the outer surface and guides the sheet S transported from the rotating drum **30** via the driven roller **34** with the back side of the sheet S facing the succeeding drive roller **32**. The succeeding drive roller **32** rotates clockwise in FIG. **1**, whereby the sheet S is transported to the winding section **4**. A nip roller **32***n* is disposed so as to oppose the succeeding drive roller **32**. The nip roller **32***n* abuts against the front side of the sheet S in a state in which the nip roller **32***n* is urged toward the succeeding drive roller **32** and the sheet S is nipped between the nip roller **32***n* and the succeeding drive roller **32**. Thus, friction force between the succeeding drive roller **32** and the sheet S is secured, so that the succeeding drive roller **32** can reliably transport the sheet S.

In this manner, the sheet S transported from the preceding drive roller **31** to the succeeding drive roller **32** is supported by the outer surface **301***a* of the rotating drum **30**. Moreover, in the processing section **3**, the processing unit **3**U is disposed to print a color image on the front side of the sheet S support by the rotating drum **30**. The processing unit **3**U includes an arc-shaped unit supporting member **35** arranged along the outer surface **301***a* of the rotating drum **30**, and the unit supporting member **35** supports print heads **36***a* to **36***e* and UV irradiators **37***a* and **37***b*.

Four print heads **36***a* to **36***d* arranged in sequence in the transport direction Ds correspond to yellow, cyan, magenta, and black and discharge the corresponding color inks from nozzles in the ink jet technique. The four print heads **36***a* to **36***d* extend radially from the rotation shaft **302** of the rotating drum **30** and are arranged along the outer surface **301***a* of the rotating drum **30**. Each of the print heads **36***a* to **36***d* is positioned with respect to the rotating drum **30** using the unit supporting member **35**, and opposes the rotating drum **30** with a slight clearance (a gap for rotation) from the rotating drum **30**. Thus, each of the print heads **36***a* to **36***d* opposes the front side of the sheet S which is guided around the rotating drum **30** with a predetermined paper gap. When each of the print heads **36***a* to **36***d* discharges an ink in a state in which the unit supporting member **35** determines the paper gap, the ink is deposited on a desired position of the front side of the sheet S, whereby a color image is formed on the front side of the sheet S.

The ink used for the print heads **36***a* to **36***d* is a UV (ultraviolet) ink (a photo-curable ink) to be cured by irradiation with ultraviolet rays (light). The processing unit **3**U is provided with UV irradiators **37***a* and **37***b* in order to cure and fix the ink on the sheet S. In this respect, the ink curing is performed in two stages, precuring and curing. Each of the UV irradiators **37***a* for precuring is disposed between two corresponding print heads in the four print heads **36***a* to **36***d*. That is, the UV irradiators **37***a* are intended to irradiate relatively weak ultraviolet rays to cure (precuring) the ink to such an extent that the shape of the ink does not change, and are not intended to completely cure the ink. On the other hand, the UV irradiator **37***b* for curing is disposed downstream of the four print heads **36***a* to **36***d* in the transport direction Ds. That is, the UV irradiators **37***b* are intended to irradiate ultraviolet rays stronger than the UV irradiators **37***a* to completely cure (curing) the ink. The precuring and the curing can be used to fix the color image formed by the plurality of print heads **36***a* to **36***d* on the front side of the sheet S.

Furthermore, a print head **36***e* is disposed downstream of the UV irradiator **37***b* in the transport direction Ds. The print head **36***e* discharges a transparent UV ink from a nozzle in the ink jet technique. The print head **36***e* is positioned with respect to the rotating drum **30** using the unit supporting member **35**, and opposes the rotating drum **30** with a slight clearance (a platen gap) from the rotating drum **30**. Thus, the print head **36***e* opposes the front side of the sheet S which is guided around the rotating drum **30** with a predetermined paper gap. When the print head **36***e* discharges an ink in a state in which the unit supporting member **35** determines the platen gap, the ink is deposited on a desired position of the front side of the sheet S, whereby a color image on the front side of the sheet S is covered with the transparent ink.

In this manner, the processing unit **3**U is constituted by the print heads **36***a* to **36***e* and the UV irradiators **37***a* and **37***b* mounted on the unit supporting member **35**. In this respect, The unit supporting member **35** extending in the X-direction bridges between two rails **351** extending in the Y-direction and freely moves on the rails **351** in the Y-direction along with the print heads **36***a* to **36***e* and the UV irradiators **37***a* and **37***b*. When printing is performed on the sheet S, the unit supporting member **35** is positioned in the print location Ta (FIG. **2**) so as to oppose the rotating drum **30**. On the other hand, when an operator performs maintenance of the print heads **36***a* to **36***e* and the UV irradiators **37***a* and **37***b*, the unit supporting member **35** is positioned in the work location Tc (FIG. **2**) away from the rotating drum **30** in the Y-direction. Thus, an operator can perform maintenance for the print heads **36***a* to **36***e* and the UV irradiators **37***a* and **37***b* in the work location Tc away from the rotating drum **30**. In this respect, to access the work location Tc, an operator opens a door (not shown) disposed on a rear side (−Y side) of the housing member **10**.

Furthermore, in the processing section **3**, the UV irradiator **38** is disposed downstream of the print head **36***e* in the transport direction Ds. The UV irradiator **38** is intended to irradiate strong ultraviolet rays to completely cure (curing) the transparent ink which the print head **36***e* discharges. Thus, the transparent ink covering the color image can be fixed on the front side of the sheet S.

The sheet S on which the color image has been formed by the processing section **3** is transported to the winding section **4** by the succeeding drive roller **32**. In addition to the winding shaft **40** around which the end of the sheet S is wrapped, the winding section **4** includes a driven roller **41** around which the sheet S is guided, disposed between the winding shaft **40** and the succeeding drive roller **32** with the back side of the sheet S facing the driven roller **41**. The winding shaft **40** supports the sheet S by winding the end of the sheet S therearound in a state in which the front side of the sheet S faces outward. That is, the winding shaft **40** rotates clockwise in FIG. **1**, whereby the sheet S having been transported from the succeeding drive roller **32** via the driven roller **41** is wound around the winding shaft **40**. In this regard, the sheet S is wound around the winding shaft **40** via a core tube (not shown) detachable from the winding shaft **40**. Therefore, when the winding shaft **40** is wound to its maximum capacity of the wound sheet S, the sheet S can be removed together with the core tube.

A UV ink discharged from the print heads **36***a* to **36***e* generates heat when it is cured by irradiation with ultraviolet rays. Thus, the heat of the UV ink is transferred via the sheet S to the rotating drum **30**, whereby the rotating drum **30** thermally expands. As a result, the gap (the platen gap) between the rotating drum **30** and the print heads **36***a* to **36***e* can vary. In particular as shown in FIG. **1**, in the printing apparatus **1** in which the UV lamps **37***a*, **37***b*, and **38** irradiate a portion of the sheet S that is guided on the rotating drum **30** with ultraviolet rays, it may become a serious problem that the heat generated when the UV ink is cured heats the rotating drum **30**, resulting in variation of the platen gap. Moreover, the rotating drum can be heated by heat generated by the UV lamps **37***a*, **37***b*, and **38** other than the heat from the UV ink. To this end, the printing apparatus **1** includes an air flow generating system which generates an air flow that passes through the hollow portion **300** of the rotating drum **30** for cooling the rotating drum **30**. Referring to FIG. **2** to FIG. **4** in addition to FIG. **1**, the air flow generating system will now be described mainly.

FIG. **2** is a plan view schematically illustrating the schematic configuration of the printing apparatus shown in FIG. **1**. FIG. **3** is a front perspective view partially illustrating the schematic configuration of the printing apparatus shown in FIG. **1**. FIG. **4** is a rear perspective view partially illustrating the schematic configuration of the printing apparatus shown in FIG. **1**. FIG. **3** and FIG. **4** show an inner configuration of the printing apparatus **1** with an upper portion of the housing member **10** removed and details of the processing unit **3**U, the sheet S, and the like omitted. FIG. **4** also shows an exhaust fan **63** when viewed through a frame member **83**.

As apparent from FIG. **2**, in the printing apparatus **1**, a print region Ra in which an image is formed on the sheet S, a path region Rb which is adjacent to the print region Ra in the rear side (−Y side) in the Y-direction, and a work region Rc which is adjacent to the path region Rb in the rear side (−Y side) in the Y-direction are disposed. The air flow generating system **6** is intended to direct the air flow through the print region Ra in which the devices (the rotating drum **30** and the like) shown in FIG. **1** are arranged, in the Y-direction and to exhaust the air through the path region Rb. Specifically, the air flow generating system **6** includes four blower fans **61** disposed on the front side in the axial direction Y (+Y side) with respect to the rotating drum **30** and six exhaust fans **62** and **63** disposed on the rear side in the axial direction Y (−Y side) with respect to the rotating drum **30**.

The four blower fans **61** are aligned in the X-direction and arranged below a horizontal virtual plane P30 which includes the center line of rotation (the center line of the cylindrical shape) of the rotating drum **30** (on the opposite side compared to the positions above the virtual plane P30 in which the print heads **36***a* to **36***e* are disposed). Each of the blower fans **61** is oriented in the axial direction Y of the rotating drum **30** and opposes the hollow portion **300**. The housing member **10** includes a louver **11** opposing the hollow portion **300** formed in the front side in the axial direction Y (+Y side), and each of the blower fans **61** takes in air through the louver **11** from the outside of the apparatus **1** and directs the air into the hollow portion **300** of the rotating drum **30**. The two blower fans **61** out of these four blower fans **61** closer to the center of the rotating drum **30** are disposed lower than the other two blower fans **61** farther away from the center of the rotating drum **30**. In this manner, the four blower fans **61** are arranged depending on the shape of the hollow portion **300**, thereby being able to blow air efficiently into the hollow portion **300**.

The six exhaust fans **62** and **63** are also disposed below the horizontal virtual plane P30 which includes the center line of rotation. These exhaust fans **62** and **63** take in air through the hollow portion **300** of the rotating drum **30** and exhaust the air through the path region Rb to the outside of the apparatus **1**. The four exhaust fans **62** out of the six exhaust fans **62** and **63** are disposed on the boundary of the print region Ra and the path region Rb with the four exhaust fans **62** being oriented away from the hollow portion **300** in the axial direction Y of the rotating drum **30**. Therefore, each of the exhaust fans **62** takes in air from the hollow portion **300** and discharges the air into the path region Rb in the axial direction Y.

On the other hand, each of the two exhaust fans **63** is arranged so as to correspond to diametrically opposite ends of the hollow portion **300** in the horizontal direction X and so as to be oriented to the right and the left, respectively, in the horizontal direction X orthogonal to the axial direction Y of the rotating drum **30**. Therefore, the exhaust fan **63** on the right side in the horizontal direction X (−X side) discharges air which has been taken in from the hollow portion **300** and has been discharged from the exhaust fan **62**, along the path region Rb toward the right side in the horizontal direction X (−X side). The exhaust fan **63** on the left side in the horizontal direction X (+X side) discharges air which has been taken in from the hollow portion **300** of the rotating drum **30** and has been discharged from the exhaust fan **62**, along the path region Rb toward the left side in the horizontal direction X (+X side). The housing member **10** includes a louver **12** at both ends of the path region Rb in the horizontal direction X, and air discharged from each of the exhaust fans **63** exits the apparatus **1** through the louver **12**.

In this manner, the air flow generating system **6** including the blower fans **61** and the exhaust fans **62** and **63** is provided. Thus, in the inside of the printing apparatus **1**, an air flow Fa is generated which passes through the hollow portion **300** of the rotating drum **30** in the axial direction Y and enters the path region Rb, and an air flow Fb which has passed from the rotating drum **30** into the path region Rb turns in the horizontal direction X and is exhausted. That is, air taken in from the outside of the apparatus **1** moves in the air flow Fa in the axial direction Y, and subsequently moves in the air flow Fb in the horizontal direction X and exits the apparatus **1**. In this case, the exhaust fans **63** oriented in the horizontal direction X are disposed ahead of the air flow Fa, so that the air flow is smoothly turned from the air flow Fa to the air flow Fb. In this manner, the exhaust fan **63** not only exhausts air from the hollow portion **300** of the rotating drum **30** but also serves as an air flow turning fan which turns the air flow.

Moreover, in the printing apparatus **1**, frame members **81**, **82**, and **83** are disposed so as to divide the print region Ra, the path region Rb, and the work region Rc. The frame members **81**, **82**, and **83** have substantially flat shapes extending in the X-direction and are arranged in the Y-direction in the order of **81**, **82**, and **83**. The frame member **81** is disposed between a front portion of the housing member **10** on the front side in the Y-direction (+Y side) and the rotating drum **30**, and includes four openings **811** aligned in the X-direction between the louver **11** and the hollow portion **300**. The frame member **81** holds the blower fans **61** in each of the openings **811**. The frame member **82** is disposed on the boundary of the print region Ra and the path region Rb, and includes four openings **821** which are aligned in the X-direction and oppose the hollow portion **300**. The frame member **82** holds the exhaust fans **62** in each of the openings **821**. Moreover, the frame member **82** divides the print region Ra and the path region Rb, and serves to block air flow between the region Ra and Rb in regions other than the hollow portion **300**. The frame member **83** is disposed on the boundary of the path regions Rb and the work region Rc to divide the path region Rb and the work region Rc and serves to block air flow between the regions Rb and Rc.

In this regard, as mentioned above, the unit supporting member **35** is free to move in the Y-direction between the print location Ta in the print region Ra and the work location Tc in the work region Rc along with the print heads **36***a* to **36***e* and the UV irradiators **37***a* and **37***b*. In order to prevent interference with the unit supporting member **35** moving across the path region Rb in this manner, the frame members **82** and **83** are configured to extend to a level lower than the moving path of the functional portions **35**, **36***e* to **36***e*, **37***a*, and **37***b*. However, in order to securely block the air flow between the regions Rb and Rc, the frame member **83** is configured to extend to a level higher than the exhaust fans **62** and **63**. Specifically, the frame members **82** and **83** extend to a level of the virtual plane P30 in the areas opposing the rotating drum **30** in the Y-direction.

The configuration of the air flow generating system **6** that generates the air flows Fa and Fb for cooling the rotating drum **30** has been described. Now, an example of the rotating drum **30** to be cooled down by the air flow generating system **6** will be described in detail. FIG. **5** is a front perspective view partially illustrating a configuration of the rotating drum. As mentioned above, the rotating drum **30** includes the hollow cylinder **301** (a rim) surrounding the hollow portion **300** penetrating therethrough in the axial direction Y and the rotation shaft **302** which is disposed in the hollow portion **300** and extends in the axial direction Y. Furthermore, as shown in FIG. **5**, the rotating drum **30** includes, in the hollow portion **300**, a plurality of arms **303** (ribs) that extend radially from the rotation shaft **302** in the radial direction and are arranged at constant angular intervals in the rotation direction Ds (the peripheral direction). The inner peripheral surface **301***b* of the hollow cylinder **301** is connected to the rotation shaft **302** via the plurality of arms **303**. In this manner, the hollow cylinder **301** is supported by the plurality of arms **303**.

Each of the arms **303** is configured to have a flat shape that tapers outwardly in the radial direction of the rotating drum **30** and has the same length as the hollow cylinder **301** in the axial direction Y. The arm **303** has the air holes **303***a*. Each of the air holes **303***a* is formed so as to be longer in the axial direction Y, to have a shape of a long hole having a width Wa in the radial direction, and to penetrate through the arm **303** in the rotation direction Ds. In each of the arms **303**, the plurality of air holes **303***a* are disposed both in the axial direction Y and in the radial direction to be arranged in a two-dimensional array. Furthermore, a fin portion **303***b* that does not have the air holes **303***a* is disposed in an outer region of the arm **303**. The fin portion **303***b* is disposed so as to extend from the inner peripheral surface **301***b* of the hollow cylinder **301** toward the rotation shaft **302** in the radial direction so as to have a width Wb which is larger than or equal to the width Wa of the air holes **303***a*. The fin portion **303***b* is disposed over the entire length of the hollow cylinder **301** in the axial direction Y.

From another viewpoint, the air holes **303***a* are disposed as follows, where the radius of the rotating drum **30** is r. That is, the total area of the air holes **303***a* disposed in a region R1 of the arms **303** which lies at a distance of r/2 or less from the center line of the rotating drum **30** in the radial direction is larger than the total area of the air holes **303***a* disposed in a region R2 of the arms **303** which lies at a distance larger than r/2 from the center line of the rotating drum **30**. In this manner, the region of the arms **303** closer to the center of the rotating drum **30** has more air holes **303***a*.

Furthermore, the rotating drum **30** has at least one auxiliary heat dissipation member **304** formed on the inner peripheral surface **301***b* of the peripheral portion **301**. The auxiliary heat dissipation member **304** has the shape of a ring that extends over the entire periphery in the rotation direction Ds (the peripheral direction) of the inner peripheral surface **301***b* of the hollow cylinder **301**. The at least one auxiliary heat dissipation member **304** may include a plurality of auxiliary heat dissipation members **304** evenly spaced apart from each other in the axial direction Y and has a sectional shape shown in FIG. **6**. FIG. **6** is a Y-direction partial sectional view schematically illustrating a section of the auxiliary heat dissipation member. As shown in FIG. **6**, each of the plurality of auxiliary heat dissipation members **304** protrudes from the inner peripheral surface **301***b* of the hollow cylinder **301** so as to have an even thickness T304 from the inner peripheral surface **301***b*. Each of the auxiliary heat dissipation members **304** has a trapezoidal shape which tapers with increasing distance from the inner peripheral surface **301***b* in the radial direction in the section in the axial direction Y. That is, the auxiliary heat dissipation member **304** includes a wall surface **304***a* that is inclined in the direction of the air flow Fa and is disposed on an upstream side of the air flow Fa passing through the hollow portion **300**. Moreover, the auxiliary heat dissipation member **304** also serves as a stiffening member for maintaining the shape of the hollow cylinder.

Then, the air flow Fa generated by the air flow generator **6** passes through the hollow portion **300** of the rotating drum **30** having the configuration shown in FIGS. **5** and **6**. As a result, heat exchange is performed between the air flow Fa and the rotating drum **30**, so that the rotating drum **30** is cooled down, whereby variation of the platen gap (the paper gap) can be suppressed. Thus, it is possible to stabilize the positions of the inks deposited on the sheet S to form an excellent image.

As described above, according to this embodiment, the rotating drum **30** includes the hollow cylinder **301** having the outer surface **301***a* around which the sheet S is guided. The print heads **36***a* to **36***e* can discharge inks onto the sheet S which is guided around the outer surface **301***a* of the rotating drum **30** to record an image on the sheet S. Moreover, The air flow generating system **6** that generates the air flow Fa passing through the hollow portion **300** of the rotating drum **30** (a portion surrounded by the hollow cylinder **301**) is disposed so that the rotating drum **30** is cooled down by the air flow Fa.

However, the rotating drum **30** includes, in the hollow portion **300**, the rotation shaft **302** that has an axis identical to the rotation axis of the rotating drum **30** extending in the axial direction Y and the arms **303** that extend from the rotation shaft **302** in the radial direction and support the hollow cylinder **301**, and rotates about the rotation shaft **302** in the rotation direction Ds. Therefore, when the rotating drum **30** rotates, the arms **303** in the hollow portion **300** also rotate in the rotation direction Ds. In addition, the rotation direction Ds of the arms **303** is a direction intersecting (substantially orthogonal to) the direction of the air flow Fa passing through the hollow portion **303**, whereby the rotating arms **303** may block the air flow Fa.

Therefore, according to this embodiment, the air holes **303***a* penetrating through corresponding arms **303** in the rotation direction Ds are provided. Therefore, the air flow Fa generated by the air flow generating system **6** passes through the air holes **303***a* in the rotation direction Ds, thereby avoiding being caught by the arms **303** rotating in the rotation direction Ds to be able to pass through the hollow portion **300**. As a result, a large amount of high-speed air flow Fa is generated and introduced into the hollow portion **300** of the rotating drum **30**, whereby the rotating drum **30** can be efficiently cooled.

As mentioned above, heating of the rotating drum **30** becomes a problem when the heat from the drum **30** thermally expands the rotating drum **30**, which causes the gap between the rotating drum **30** and the print heads **36***a* to **36***e* to vary. In particular, expansion of the outer surface **301***a* of the rotating drum **30** considerably affects the gap between the rotating drum **30** and the print heads **36***a* to **36***e*. Therefore, it is important to efficiently cool the hollow cylinder **301** of the rotating drum **30** on which the outer surface **301***a* is formed. In this respect, the arms **303** in this embodiment include the fin portion **303***b* that does not have the air holes **303***a* and that has the width Wb from the inner peripheral surface **301***b* of the hollow cylinder **301** to the rotation shaft **302** in the radial direction. In such a configuration, while a large amount of high-speed air flow Fa is secured in the hollow portion **300** by the air holes **303***a* disposed in a region other than the fin portion **303***b*, the air flow Fa can sufficiently impinge on a portion of the arms **303** which is close to the hollow cylinder **301** (the fin portion **303***b*). As a result, the hollow cylinder **301** can exchange heat via the fin portion **303***b* with a large amount of the high-speed air flow Fa, whereby the hollow cylinder **301** can be efficiently cooled.

In particular, the width Wb of the fin portion **303***b* in the radial direction has a length larger than or equal to the width Wa of the air hole **303***a* in the radial direction. The fin portion **303***b* has the width Wb (≥Wa) in this manner, whereby the hollow cylinder **301** can be efficiently reliably cooled.

According to this embodiment, the total area of the air holes **303***a* disposed in a region of the arm **303** which lies at a distance of r/2 or less from the center line of the rotating drum **30** in the radial direction is larger than the total area of the air holes **303***a* disposed in a region of the arms **303** which lies at a distance larger than r/2 from the center line of the rotating drum **30** (where r is the radius of the rotating drum **30**). In such a configuration, more air holes **303***a* are disposed in a region of the arms **303** which is close to the center of the rotating drum **30**, whereby the air flow F does not pass through and is blown toward the region of the arms **303** which is close to the hollow cylinder **301**. As a result, the hollow cylinder **301** can exchange heat with a large amount of the high-speed air flow Fa, whereby the hollow cylinder **301** can be efficiently cooled.

Furthermore, according to this embodiment, the plurality of air holes **303***a* are disposed in each of the arms **303** in the radial direction between the inner peripheral surface **301***b* of the hollow cylinder **301** and the rotation shaft **302**. Also in the axial direction Y, the plurality of air holes **303***a* are disposed in each of the arms **303**. Because the plurality of air holes **303***a* are disposed in each of the arms **303** in this manner, the arms **303** can effectively suppress blocking of the air flow Fa, so that a large amount of the high-speed air flow Fa can be generated into the hollow portion **300** of the rotating drum **30**, whereby the cooling efficiency of the rotating drum **30** can be improved.

Moreover, according to this embodiment, the auxiliary heat dissipation member **304** is also disposed on the inner peripheral surface **301***b* of the hollow cylinder **301** in addition to the arms **303**. In such a configuration, the air flow Fa can sufficiently impinge on the auxiliary heat dissipation member **304** disposed on the hollow cylinder **301**, so that the hollow cylinder **301** can exchange heat via the auxiliary heat dissipation member **304** with a large amount of the high-speed air flow Fa, whereby the hollow cylinder **301** can be efficiently cooled.

In particular, according to this embodiment, the auxiliary heat dissipation member **304** is formed in the shape of a ring that extends over the entire periphery in the peripheral direction of the inner peripheral surface **301***b* of the hollow cylinder **301**. The auxiliary heat dissipation member **304** is disposed in this manner to be able to promote heat exchange between the air flow Fa and the hollow cylinder **301** via the auxiliary heat dissipation member **304**, whereby the hollow cylinder **301** can be efficiently reliably cooled.

In addition, the auxiliary heat dissipation member **304** includes the wall surface **304***a* that is inclined in the direction of the air flow Fa and is disposed upstream of the air flow Fa. In this manner, the wall surface **304***a* which the auxiliary heat dissipation member **304** includes upstream of the air flow Fa is inclined in the direction of the air flow Fa, whereby the blocking of the air flow Fa can be suppressed by the wall surface **304***a* of the auxiliary heat dissipation member **304**.

Furthermore, the at least one auxiliary heat dissipation member **304** includes a plurality of auxiliary heat dissipation members **304** disposed in the axial direction Y. Each of the auxiliary heat dissipation members **304** has an even thickness T304 from the inner peripheral surface **301***b* of the hollow cylinder **301**. In this manner, the plurality of auxiliary heat dissipation members **304** have the same thickness T304, whereby the blocking of the air flow Fa can be suppressed by the auxiliary heat dissipation member **304**.

In this manner, in this embodiment, the printing apparatus **1** corresponds to an example of "an image recording apparatus" of the invention, the rotating drum **30** corresponds to an example of "a rotating drum" of the invention, the hollow portion **300** corresponds to an example of "a hollow portion" of the invention, the hollow cylinder **301** corresponds to an example of "an hollow cylinder" of the invention, the outer surface **301***a* corresponds to an example of "an outer surface" of the invention, the inner peripheral surface **301***b* corresponds to an example of "an inner peripheral surface" of the invention, the rotation shaft **302** corresponds to an example of "a shaft member" of the invention, the arms **303** correspond to an example of "supporting members" of the invention, the air holes **303***a* correspond to an example of "air holes" of the invention, the fin portion **303***b* corresponds to an example of "a fin portion" of the invention, the auxiliary heat dissipation member **304** corresponds to an example of "an auxiliary heat dissipation member" of the invention, the rotation direction Ds corresponds to an example of "a rotation direction" of the invention, the air flow generating system **6** corresponds to an example of "an air flow generator" of the invention, the air flow Fa corresponds to an example of "an air flow" of the invention, the print heads **36***a* to **36***e* correspond to an example of "discharge heads" of the invention, the UV lamps **37***a*, **37***b*, and **38** correspond to an example of "light irradiators" of the invention, the sheet S corresponds to an example of "a recording medium" of the invention, and the UV ink corresponds to an example of "a liquid" of the invention.

In this respect, the invention is not intended to be limited to the above embodiments, and various modifications may be made to the above-mentioned embodiments without departing from the scope of the invention. For example, in the above embodiments, the heat which expands the rotating drum **30** in the application of the invention has been described to be curing reaction heat of the UV ink. However, the heat source which expands the rotating drum **30** is not limited to the UV ink. Therefore, the invention is preferably applicable even if a driving source such as a motor or an actuator is the heat source. Consequently, the invention is applicable to the printing apparatus **1** without using a UV ink.

Moreover, the shape, the number, the arrangement, or the like of the arms **303** may be appropriately modified. Moreover, the shape, the number, the arrangement, or the like of the air holes **303***a* disposed on the arms **303** may be appropriately modified, and for example, the area which the air holes **303***a* occupy on the arms **303** is not limited to the above mentioned area.

Furthermore, the arrangement of the fin portion **303***b* disposed on the arms **303** may be appropriately modified. Therefore, it is not necessary to dispose the fin portion **303***b* over the entire length of the hollow cylinder **301** in the axial direction Y. The fin portion **303***b* may be disposed over the partial length of the hollow cylinder **301**. Alternatively, the fin portion **303***b* may be omitted.

Moreover, the shape, the number, the arrangement, or the like of the auxiliary heat dissipation member **304** disposed on the rotating drum **30** may be appropriately modified. Alternatively, the auxiliary heat dissipation member **304** may be omitted.

Moreover, various modifications may be made to the air flow generating system **6**. Therefore, the number, the arrangement, or the like of the blower fans **61** and the exhaust fans **62** and **63** also may be appropriately modified. Alternatively, the air flow generating system **6** may be constructed so as to generate the air flow Fa only by the blower fans **61** or only by the exhaust fans **62**.

Furthermore, the number, the arrangement, or the like the print heads **36***a* to **36***e* and the UV lamps **37***a*, **37***b*, and **38** may be properly modified. Therefore, for example, the UV lamps **37***a*, **37***b*, and **38** are not necessarily disposed so as to oppose a portion of the sheet S that is guided on the rotating drum **30**.

The entire disclosure of Japanese Patent Application No. 2013-054689, filed Mar. 18, 2013 is expressly incorporated by reference herein.

What is claimed is:

1. An image recording apparatus, comprising:

a rotating drum including a hollow cylinder around which a recording medium is guided while the rotating drum rotates;

a discharge head, opposing an outer surface of the rotating drum, that discharges liquid onto the recording medium guided around the outer surface of the rotating drum; and

an air flow generator that generates an air flow that enters the hollow cylinder axially, passes through the inside of the hollow cylinder of the rotating drum, and exits the hollow cylinder axially;

wherein the rotating drum further includes, in the hollow cylinder, a shaft member that has an axis identical to a rotation axis of the rotating drum and supporting members that are plate-shaped and that extend from the shaft member in the radial direction of the rotating drum and support the hollow cylinder, and the rotating drum rotates in a rotation direction about the shaft member,

wherein each of the supporting members includes at least one air hole penetrating therethrough in the rotation direction.

2. The image recording apparatus according to claim **1**,

wherein the total area of the at least one air hole disposed in a region of the supporting member which lies at a distance of r/2 or less from the rotation axis of the rotating drum in the radial direction is larger than the total area of the at least one air hole disposed in a region of the supporting member which lies at a distance larger than r/2 from the rotation axis of the rotating drum, where the radius of the rotating drum is r.

3. The image recording apparatus according to claim **1**,

wherein the supporting member includes a fin portion that does not have the at least one air hole and that has a width in the radial direction from the inner surface of the hollow cylinder toward the shaft member.

4. The image recording apparatus according to claim **3**,

wherein the width of the fin portion in the radial direction is equal to or larger than the width of the at least one air hole in the radial direction.

5. The image recording apparatus according to claim **1**,

wherein the at least one air hole includes a plurality of air holes in the radial direction between the inner surface of the hollow cylinder and the shaft member.

6. The image recording apparatus according to claim **1**, wherein the at least one air hole includes a plurality of air holes in the axial direction.

7. The image recording apparatus according to claim **1**, wherein the rotating drum further includes an auxiliary heat dissipation member on the inner surface of the hollow cylinder in addition to the supporting members.

8. The image recording apparatus according to claim **7**, wherein the auxiliary heat dissipation member has the shape of a ring that extends over the entire periphery in the peripheral direction on the inner surface of the hollow cylinder.

9. The image recording apparatus according to claim **1**, wherein the auxiliary heat dissipation member includes a wall surface that is inclined in the direction of the air flow and that is disposed on an upstream side in the direction of the air flow.

10. The image recording apparatus according to claim **1**, wherein the discharge head further includes a light irradiator that irradiates a liquid having been discharged onto the recording medium with light,

wherein the liquid is a photo-curable liquid which generates heat when it is cured by irradiation with light,

wherein the light irradiator irradiates a portion of the recording medium that is guided around the rotating drum with light.

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